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Report from the Conference of the Swedish National Committee for Physics in 1955

By Gudmund Borelius and Erik Rudberg

On September 26–28, 1955, the Swedish National Committee for Physics held its eighth general physics conference. Once again the Royal Institute of Technology, Stockholm, had generously invited the Swedish physicists and their guests to use its lecture halls and other excellent facilities for the meeting. The large number of contributed papers made it necessary to use all three days for presentation and discussion of these research reports. Most of the time two sessions were run in parallel. Short summaries of these papers are given in this communication.

As Secretary for the conference the National Committee for Physics had the good fortune to secure the services of Tekn. Lic. Eric Hellstrand of the Atomic Energy Laboratory, Stockholm, to whom much credit is due for the success of the meeting.

Bo Aler, *Research Institute of National Defence, Stockholm*

γ-Doses from mixed fission products

From fission yield data and known decay schemes the number of disintegrations of various fission products from simultaneous fission of U 235 and Pu 239 were calculated from 1 hour to 100 years after the moment of fission. The γ-spectra and the average energies of the γ-rays were given for the same periods. From available data on γ-transmission the dose from an infinite plane covered with mixed fission products was calculated, and the relevance of using the average energies for this computation was discussed. Experimental spectra from reactor-produced fission products were shown for the period 1.5 hours to 30 days.

The effect on the natural background produced by the deposition of fission products from atomic weapons tests was discussed. For a year, July 1954 to June 1955, the total amount of fission products has been equivalent to 0.15 μC/m^2 as measured at the time of arrival. The resulting intensity in the open was estimated to be less than 1 μr/hour, disregarding weathering. The amount of Sr^{90} deposited in the same period was approximately 5×10^{-4} μC/m^2.

In this work have participated: R. Björnerstedt, K. Löw, S. Ulvönäs, B. Jung, K. Edvarson, and D. Dyrssen.

OLLE ALMÉN, *Department of Physics, Chalmers Institute of Technology, Gothenburg*

Development of ion sources

In the course of time, a number of ion sources have been tried. At present two magnetic types are used exclusively, with the magnetic field either parallel or perpendicular to the direction of the extracted ion beam.

An ion source of the former design was developed at the Institute for Theoretical Physics in Copenhagen, with the particular purpose of separating radioactive materials. The source is operating with a hot discharge chamber, which is connected to an externally heated oven (up to 1200°C) for the evaporation of solids. In order to be able to separate shortlived isotopes, e.g., from the cyclotron of the Institute, the oven may be introduced to the high vacuum through a valve, after it has been filled with the active charge material. Considerable freedom in the choice of mass markers is obtained, since gases and evaporated solid materials may be added to the source simultaneously. The source operates with small amounts of charge material and, since the ratio of the number of atomic ions to the total number of atoms leaving the source is rather high, separations may be carried out with large efficiency. The ion source has in particular been used in the preparation of radon sources for β-spectrometry; in this case Pb or Bi were used as mass markers. The ion source has proved successful in producing ion beams of Mg, Zn, Kr, Sn, Sb, Hg (from HgO containing Hg^{203} with a half-life of 45 days).

An ion source of the second type was developed at Chalmers Institute of Technology. The discharge chamber, of small dimensions, is made of pyrophylite. In order to produce atomic ions from solids, the vapour of the charge material is directed into the discharge chamber. In case of elements of higher melting point, such as e.g. Pa, Ni and Cr, the charge material is deposited in a tungsten spiral, which is bombarded by the electrons from the filament.

BENGT ANDERSSON, *Department of Physics, Chalmers Institute of Technology, Gothenburg.*

Precision measurements of γ-ray energies

Measurements were made with a curved crystal γ-ray spectrometer, which has been described during the Physics Conference in Stockholm in 1952.[1] The apparatus has since been improved and partly rebuilt. The crystal holder has been equipped with new adjustment arrangements, so that it can now be rotated about three axes through the centre of the crystal. The source holder has been replaced by a new one, which is equipped with adjustment screws for the position of the slit and the relative position of the source with respect to the slit. The range has been increased so as to make possible measurements down to 0.04 MeV (previously 0.15 MeV). The new screw for the scale is 70 cm long and has a pitch of 0.5 mm. The angle screw has also been made longer. The scintillation counter has been equipped with a one-channel differential discriminator. A Du Mont 6292 tube is used as a photo-multiplier. The dimensions of the NaI(Tl) crystal are $1\,{}^{3}/_{4}'' \times {}^{1}/_{2}''$.

Wavelengths and energies of γ-lines of Au^{198}, As^{76}, Sb^{122}, Eu^{152}, Eu^{154}, Yb^{175}, Lu^{177}, Re^{186}, Re^{188}, Ir^{192} and Ir^{194} have been measured.

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[1] B. ANDERSSON, Arkiv f. Fysik 7, 73 (1953).

N. E. ANDERSSON, *Department of Physics, University of Lund*

The corona hygrometer

By using a suitable type of corona discharge it has been possible to construct a fast, continuously registrating hygrometer. Beside the common positive point corona in this type of discharge, so-called streamers are formed, which advance about 4 mm into the gap as thin thread-like discharges. The number of streamers formed per second is dependent on the humidity of the air surrounding the point. At 100 per cent relative humidity and 20°C this number is about 10 000, at 30 per cent humidity it is only 50 or less. Every streamer formed gives rise to a current pulse in the electrical circuit. The number of such pulses formed per time is measured by means of a counting rate meter circuit and can be read on a galvanometer or can be continuously recorded by a Speedomax recorder. The instrument measures the humidity of air flowing at a rate as low as 5 cm^3/sec with an accuracy of 1 per cent in the range of 30 to 100 per cent relative humidity, at room temperature.

H. ATTERLING, *Nobel Institute of Physics, Stockholm*

Further work on cyclotron acceleration of heavy ions

After a recent change of the cyclotron frequency (from 8.7 to 8.1 megacycles per second) the 225-cm cyclotron at the Nobel Institute of Physics, Stockholm, can accelerate ions with a mass-to-charge ratio up to about 3.7. One object of the frequency change was to make possible the acceleration of multiply charged neon ions with 6 charges. Useful intensities have now been obtained of both $^{20}Ne^{6+}$ and $^{22}Ne^{6+}$ ions. Using neon enriched to nearly 100 per cent in ^{22}Ne, currents of 0.02 μA of $^{22}Ne^{6+}$ ions, with energies greater than 140 MeV, have been measured.

L. BECKMAN, *Research Institute of National Defence, Stockholm*

A new van de Graaff generator for 1.5 MeV

A new van de Graaff generator for 1.5 MeV has been constructed at the Research Institute of National Defence, 2nd Division. The generator will first be used as a X-ray source, but will probably later be changed to a positive ion accelerator. A resistance network has been used at the construction in order to determine the potential fields in the generator. The accelerating tube has been arranged in such a way as to avoid secondary electron multiplication when the tube is used for positive ion acceleration.

O. BECKMAN, *Department of Physics, University of Uppsala*

Relative intensities of the X-ray *K* lines of heavier elements

The relative intensities of the X-ray lines in the *K* spectra of the elements 73 Ta–83 Bi, 90 Th and 92 U have been measured by means of a curved crystal spectrometer in connection with the 800 kV van de Graaff generator of the institute. The X-radiation has been registered by a scintillation counter with a NaI (Tl) crystal and a single channel discriminator. Corrections have been made for varying efficiency of the scintillation counter, for X-ray absorption within the target and in the X-ray beam and for variation of the reflection properties of the spectrometer crystal with wavelength.

The calculated intensities are in general agreement with the theoretically determined values. A slight deviation from the 2:1 rule for the intensity ratio of some doublets has been observed, however.

A weak line resulting from the transition K to L_{I} has been detected in the spectrum of tungsten and gold. The intensity is 0.2:100 relative to that of the α_1-line.

R. BJÖRNERSTEDT, *Research Institute of National Defence, Stockholm*

Some studies of bell type GM-counters

The stability of bell type GM-counters has been investigated. It is shown how charging of insulator surfaces may cause variations in counting efficiency. The development and construction of a reliable GM-counter is described.

HJÖRDIS CELANDER, *Research Institute of National Defence, Stockholm*

The shock tube: an instrument for the production of plane shock waves in gases

A cylindrical shock tube is described. Theoretical formulae and diagrams are given for the properties of the shock produced by bursting a membrane between the high and low pressure parts of the tube. Observed shock properties and tube operating range, as well as some applications, are discussed.

J. CEDERLUND, *Laboratory for Radiophysics, Lund*

On the use of thin crystals in scintillation spectroscopy of γ-rays

In scintillation spectroscopy of γ-ray lines the present trend is generally towards use of ever larger crystals, in order to secure total absorption of the γ-quanta. When measuring the intensity of a weak γ-ray line of low energy in the presence of several strong γ-ray lines of high energy, it may, however, be advantageous to use thin crystals, in order to suppress the background. The usefulness of this method is illustrated by an investigation of the platinum K X-rays from a radium source in a platinum container.

G. DAHLÉN, *Research Institute of National Defence, Stockholm*

A portable γ-intensimeter with a large measuring range

The instrument has an ionization chamber with a sub-miniature electrometer tube inside, whose grid wire is directly connected to the inner electrode of the chamber ("floating grid"). With this arrangement the plate current of the tube is nearly proportional to the logarithm of the ion current due to radiation, within a very large range. The model instrument has a total measuring range from 0.5 mr/h to 500 r/h, split into two ranges, and with an accuracy of ± 10 per cent. The instrument also has a good stability against decreasing filament and plate voltage, which means that the instrument can be battery-operated without any compensation for decreasing battery voltage. The model instrument has a service life of more than 500 hours of continuous operation, before the batteries need replacement. Because of the construction of the instrument it has been found to be ideal for long range, remote control radiation detection without the addition of secondary amplification. In that case the ionization chamber and the meter can be separated.

E. DJURLE, *Department of Physics, Royal Institute of Technology, Stockholm*

A registering phase contrast refractometer for streaming gases and liquids

In the phase contrast refractometer the phase difference of the light from the measuring and the reference parts of the refractometer cell is converted into an intensity ratio for the corresponding parts in the image of the cell. A recording intensity ratiometer with one photomultiplier tube has been designed, and preliminary results have been obtained.

J. A. MC DONELL and I. BERGSTRÖM, *Nobel Institute of Physics Stockholm*

The isomers $Pb^{204\,m}$ and $Pb^{202\,m}$

The conversion lines of the three gamma rays in cascade following the decay of Pb^{204m} have been studied, using the double-focusing spectrometer, with various resolutions in the range 0.15–0.35 per cent. The energies of the three gammas are found to be 911.7 ± 0.3 keV, 899.3 ± 0.3 keV and 374.7 ± 0.4 keV. We have also remeasured the half-life of this isomer, which we find to be 67.5 ± 0.5 minutes. The intensity ratio of the K-conversion lines of the two higher energy gammas has been measured as $K\ 899/K\ 912 = 0.132 \pm 0.005$. This value suggests that the two transitions are pure $E5$ (912 keV) and pure $E2$ (899 keV), for in this case, the theoretical intensity ratio is 0.128. Measurements of other workers would suggest a $1\frac{1}{2}$ per cent admixture of $M6$ in the $E5$ transition, and this would lead to a theoretical value of 0.113 for the above ratio. No evidence for any other gamma ray having the 67 min. half-life has been found.

In the decay of 3.7 h Pb^{202m}, further gamma rays have been found, although it is not yet possible to say whether they are converted in Pb or in Tl. These new gamma rays (490 keV, 531 keV and 547 keV) do not appear to fit into the existing decay scheme.

K. EDVARSON and K. SIEGBAHN, *Department of Physics, University of Uppsala*

Some high resolution investigations of conversion lines

Some of the stronger conversion lines in $Th(B + C + C'')$ have been investigated in an iron-free double-focusing spectrometer. Using source widths of 0.05 mm and a transmission of about 0.3‰, half widths of 0.15‰ have been obtained. The line positions have been determined with an accuracy of 1:10^5. The $B\varrho$ values, in Gauss · cm, are computed from the $B\varrho$ ratios and X-ray data.

At the resolution used, the difference in line-width between K lines and L, M lines is quite prominent. This necessitates great care in the comparison of the positions of K lines and other lines. For that reason the ThB $F - I$-ratio was determined from photographic records of the lines.

The following $B\varrho$ values were obtained:

F	I	I_a	J	A	B
1 388.45 ± 0.10	1 753.91 ± 0.14	1 757.07 ± 0.14	1 811.11 ± 0.15	534.21 ± 0.03	652.40 ± 0.04

G. Ekspong, *Department of Physics, University of Uppsala*

Bremsstrahlung for 100–1000 MeV electrons

The aim has been to determine the total cross-section for Bremsstrahlung, ϕ_{rad}, in nuclear emulsions. The method applied gives directly the related quantity $R = (N\phi_{\text{rad}})^{-1}$, where N is the number of atoms per cm^3. The electrons have been obtained in high altitude balloon flights. The type of emulsion was Ilford G5.

The method consists in following the relative decrease of the mean energy with the distance traversed for a sample of electrons. From the exponential degradation of the mean energy, the radiation length, R, may be obtained in absolute measure. The energy was determined by a measurement of the multiple scattering in a good microscope. After application of necessary corrections the final result is:

$R = 31 \pm 5$ mm (30.3) for 100–250 MeV electrons
$R = 29 \pm 4$ mm (29.4) for 250–1000 MeV electrons
$R = 29 \pm 3$ mm (29.8) for 100–1000 MeV electrons

The experimental uncertainty is given as the standard error. The bracketed values are those calculated from the Bethe-Heitler theory.

K. B. Eriksson, *Department of Physics, University of Lund*

Observed and theoretical structure of the configuration $2p5g$ in singly-ionized nitrogen

The spectrum of singly-ionized nitrogen has been studied using a spark-generated high frequency electrodeless discharge. A group of lines representing the transition $4f$–$5g$ has been observed in the region 9694–10 126 Å. The $5g$ levels occur in close pairs with a separation of less than 0.20 cm^{-1}. The relative arrangement of the pairs can be described exactly in terms of two parameters, viz., the $2p$-electron spin-orbit integral and the largest electrostatic integral.

T. Eriksson and S. Köhler, *Department of Theoretical Physics, University of Uppsala*

Polarization of high energy protons, scattered elastically by nuclei

The polarization of protons, scattered elastically by nuclei, has been calculated for different energies of the incident protons. The nucleus was represented by a spherical, complex, spin-dependent potential. The calculations were performed according to the method of partial waves, and the phase shifts were calculated by means of the high energy limit of the WKB method. The theoretical results show a general agreement with the experimental Harwell results reported by Rose.

INGA FISCHER-HJALMARS, *Department of Theoretical Physics, University of Stockholm*

The electronic structure of the ozone molecule

Using the interatomic distances known from microwave experiment,[1, 2] the electronic structure of the ozone molecule has been studied by the molecular orbital method in the linear combination of atomic orbitals approximation. The ozone molecule belongs to the point group C_{2v}. The irreducible representations of this group are denoted[3] by a_1, b_1, a_2 and b_2. The wave function Ψ_0 of the ground state belongs to the species ${}^1A_1$. The electron configuration mainly contributing to the ground state is

$$\Psi_{01} = KKK\,(a_1')^2\,(b_1')^2\,(a_1'')^2\,(b_1'')^2\,(a_1''')^2\,(b_2')^2\,(b_1''')^2\,(a_1^{\text{iv}})^2\,(a_2)^2.$$

The coefficients and energy parameters of the one-electron orbitals have been computed in two different approximations: (1) the $2p$-approximation ($1s$ and $2s$ electrons completely localized), and (2) the $2s$, $2p$-approximation (only $1s$ electrons localized). The computed values of dissociation energy, dipole moment and the lowest ionization potentials are given in the table.

	$2p$-appr.	$2s$, $2p$-appr.	Exptl.
Dissociation energy	37 eV	10 eV	
Dipole moment	1.1 D	1.1 D	0.55 D
Ionization potential of orbital a_2	15.5 eV	12.4 eV	
a_1^{iv}	17.2 eV	13.7 eV	
b_1'''	14.5 eV	14.3 eV	

H. F. FISCHMEISTER, *Department of Chemistry, University of Uppsala*

The thermal expansion of sodium chloride at high temperatures

X-ray measurements from room temperature to the melting point are reported which confirm the non-linearity of the thermal expansion of NaCl previously observed by dilatometric methods.[4, 5] Within the limits of experimental accuracy (about 0.1 per cent in $\Delta a/a$), the X-ray and dilatometric expansion curves coincide up to the melting point.

The concentration of lattice defects, as extrapolated from conductivity data[6], is too small—even at the melting point—to cause a volume effect detectable with

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[1] R. H. HUGHES, Phys. Rev. *85*, 717 (1952); J. Chem. Phys. *21*, 959 (1953).

[2] TRAMBARULO, GHOSH, BROWN, and GORDY, J. Chem. Phys. *21*, 851 (1953).

[3] G. HERZBERG, Molecular Spectra and Molecular Structure II. Infrared and Raman Spectra of Polyatomic Molecules. New York 1945, p. 106.

[4] EUCKEN and DANNÖHL, Z. Elektrochem. *40*, 814 (1934).

[5] STRELKOW, Phys. Zs. Sowjetunion *12*, 35 (1937).

[6] ETZEL and MAURER, J. Chem. Phys. *18*, 1003 (1950).

the apparatus employed. Thus, the non-linearity of the expansion cannot be due to lattice defects. Instead, it is quantitatively accounted for by the lattice dynamical theory of thermal expansion developed[1] by Debye and Grüneisen.

H. F. FISCHMEISTER, *Department of Chemistry, University of Uppsala*

Spatial aspects of group rotation in the alkali nitrates

X-ray measurements on the hexagonal modifications of $LiNO_3$, KNO_3 and $AgNO_3$ are reported and compared with published[2] data on $NaNO_3$. The following cell constants and coefficients of expansion were obtained (within the experimental accuracy, the expansion is linear over the whole range of stability):

	Temperature range of stability °C	Hexagonal cell constants at extreme temperatures	Coefficient of thermal expansion in $10^{-6}(°C)^{-1}$	
			$\parallel a$	$\parallel c$
$LiNO_3$	up to 251.4	$a_{20} = 4.692$ Å $c_{20} = 15.206$ Å $a_{251.4} = 4.729$ Å $c_{251.4} = 15.577$ Å	+ 34	+ 103
$NaNO_3$ (data from [2])	275–310	$a_{275} = 5.075$ Å $c_{275} = 17.523$ Å $a_{310} = 5.075$ Å $c_{310} = 17.607$ Å	± 0	+ 136
KNO_3	128–335	$a_{128} = 5.423$ Å $c_{128} = 19.277$ Å $a_{335} = 5.420$ Å $c_{335} = 20.590$ Å	− 8	+ 308
$AgNO_3$	159.4–210	$a_{159.4} = 5.168$ Å $c_{159.4} = 16.903$ Å $a_{210} = 5.174$ Å $c_{210} = 17.018$ Å	+ 23	+ 134

There is a distinct correlation between the anisotropy of the expansion and the *degree* of disorder in the crystal as estimated from a comparison of the entropies of fusion with those of the corresponding halides. The *nature* of the disorder (rotational or orientational) can be clarified by spatial considerations.

The spatial requirements for free rotation (in the sense of actual spinning of the molecules) are not satisfied in either the above or in the cubic high temperature forms of any alkali nitrate. Instead, analysis of the spatial conditions indicates the existence of disorder of the NO_3^- group between two angular positions as suggested—for $NaNO_3$—by Siegl.[3]

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[1] GRÜNEISEN, Handbuch d. Physik X, pp. 1–59. Berlin 1926.

[2] J. B. AUSTIN and R. H. H. PIERCE, Journ. Am. Chem. Soc. *55*, 661 (1933).

[3] L. A. SIEGL, J. Chem. Phys. *17*, 1146 (1949).

With this atomic arrangement, the transition low–high provides (in all crystals of this group, including even $RbNO_3$) increased freedom of vibration along the trigonal axis, i.e. perpendicular to the plane of the nitrate ions. The strong expansion in this direction suggests that this mode of vibration is indeed effectively activated, and the small (or negative) expansion $\| a$ suggests the absence of rotational motion.

The degree of rotational freedom left to the nitrate ion by the spatial conditions varies with the cation. No correlation prevails, however, with the variation of the entropy of fusion. Remembering, on the other hand, the good parallelism of this quantity with the thermal expansion, the conclusion must be drawn that the rotational modes are less important in the high temperature modifications than the vibration perpendicular to the plane of the nitrate group.

BENGT FORKMAN, *Department of Physics, University of Lund*

The ratio of photodeuterons to photoprotons from some elements

An investigation of the ratio between protons and deuterons ejected from Co and Cu was made. Thin metal foils were irradiated by 30 MeV Bremsstrahlung from the synchrotron at Lund. The particles were detected in nuclear emulsions. The emulsions were placed out of reach of the direct synchrotron beam, in an evacuated camera with the target in the centre. Grain counting on the last 40 μ of the tracks was used to separate the two kinds of particles. The experimental ratio of deuterons to protons from Co and Cu targets is 0.22 and 0.16, respectively.

L. FORNAEUS, *Research Institute of National Defence, Stockholm*

Two instruments for the photographic study of rapid events

In connection with the research program in the detonation field, some instruments have been made for the work on this subject.

The *Kerr Cell Shutter* gives single-exposures, with an exposure time less than 0.05 μs. The cell has an aperture of 20 × 20 mm and a length of 20 mm.

The shutter is used in connection with a single-eyed reflex-camera, with a picture size 24 × 36 mm. The lens is placed in front of the Kerr cell. Its focal length is 8″, and the aperture is 1:2.9. The effective aperture of the lens and the Kerr cell together is about 1:4, the absorption effects of the polaroids and the nitrobenzene not included.

The *X-Ray Flash* gives very short flashes, with a duration of about 0.1 μs.

The equipment consists of a X-ray tube with pumps and vacuum gauges, condenser battery, and high voltage supply.

The X-ray tube is of the three-electrode type and is made of a steel cylinder and a ceramic insulator.

The condenser battery is arranged as a "Marx-Generator" in five steps. As a maximum it can be charged to 80 kV, giving a pulse voltage of 400 kV. The effective capacity when discharged is 0.02 μF.

CARL-ERIK FRÖBERG, *Department of Theoretical Physics, University of Lund*

Numerical treatment of Coulomb wave functions

The Coulomb wave functions $F_L(\eta, \varrho)$ and $G_L(\eta, \varrho)$ which depend on three variables ϱ, η and L, are most important in many physical problems, especially in the scattering theory of charged particles. The corresponding differential equation is usually written in the standard form: $\{d^2/d\varrho^2 + 1 - 2\eta/\varrho - L(L+1)/\varrho^2\}y = 0$. Here L is supposed to be an integer, and then it can be shown that e.g. F_{L+1} can be obtained as a linear combination of F_L and F'_L. The problem is thus reduced to the case $L = 0$, but even here quite different methods of computation must be used. In a (ϱ, η)-plane we find that close to the η-axis expansion in power series or in a series of Bessel-Clifford functions is adequate, close to the ϱ-axis an asymptotic expansion should be preferred, while close to the transition line $\varrho = 2\eta$ an expansion in Airy integrals or numerical quadrature seems to be the most powerful method. In the remaining regions a Riccati method gives the best results.

A more detailed description will be published in *Reviews of Modern Physics.*

P. O. FRÖMAN and H. B. RYDE, *Department of Physics, University of Lund*

An experimental study of the decay scheme of Ta^{182} by means of a coincidence scintillation spectrometer

The energies of the γ-rays following the β^--decay of Ta^{182} have been accurately measured by J. J. Murray *et al.*[1] by means of a curved crystal spectrometer, and a level scheme of the daughter nucleus, W^{182}, of Ta^{182} has also been given by these authors. In a recent paper by G. Alaga *et al.*[2] the Bohr-Mottelson nuclear model has been applied to the nucleus W^{182}, and a classification of the energy levels into different rotational bands has been made. To check this level scheme it is of some interest to use coincidence methods for studying the β^--decay of Ta^{182}, but so far there exists only a very incomplete investigation of this kind, which is due to J. W. Mihelich.[3] Using a coincidence scintillation spectrometer devised by S. A. E. Johansson and S. Almquist,[4] we have investigated this decay scheme more in detail. Although the interpretation of our experimental results is not yet completed, a preliminary survey of them supports the above-mentioned results[1, 2] both as regards the γ–γ-coincidences and the β–γ-coincidences.

T. R. GERHOLM and H. DE WAARD[5], *Department of Physics, University of Uppsala*

Short half-lives of excited states in Pr^{141}, La^{139}, I^{131} and Tl^{203}

The delayed coincidence technique was used to measure the half-lives of the following excited nuclear states: 145 keV level in Pr^{141} $T_{1/2} = (19 \pm 2) \cdot 10^{-10}$ sec., 163 keV level in La^{139} $T_{1/2} = (15 \pm 1) \cdot 10^{-10}$ sec., 147 keV level[6] in I^{131} $T_{1/2} \sim 10^{-10}$ sec. and 279 keV level in Tl^{203} $T_{1/2} = (1.2 \pm 0.3) \cdot 10^{-10}$ sec.

The coincidence rate was automatically recorded for a number of different delays, utilizing a unit with a helical delay line. The sources and suitable absorbers were sandwiched between thin stilbene crystals attached to IP21 photomultiplier tubes.

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[1] J. J. MURRAY, F. BOEHM, P. MARMIER, and J. W. M. DUMOND, Phys. Rev. *97*, 1007 (1955).

[2] G. ALAGA, K. ALDER, A. BOHR, and B. R. MOTTELSON, to be published in Dan. Mat. Fys. Medd.

[3] J. W. MIHELICH, Phys. Rev. *95*, 626 (1954). Cf. also Bull. Am. Phys. Soc. No. 4, p. 38 (1954).

[4] S. A. E. JOHANSSON and S. ALMQUIST, Arkiv för Fysik *5*, 427 (1952). S. A. E. JOHANSSON, Iowa State College 431 (1953).

[5] On leave from the Physical Laboratory, University of Groningen, Netherlands.

[6] The half-life value given should be regarded as a preliminary value.

The first three transitions studied occur between $d\,{}^5/_2$ and $g\,{}^7/_2$ levels and are of predominantly magnetic dipole character. The $d\,{}^3/_2$–$s\,{}^1/_2$ transition in Tl^{203} is a mixture of magnetic dipole and electric quadrupole radiations. Comparison with Weisskopf's formula for single particle transitions shows that the M_1 transitions are retarded by factors between 200 and 400.

A. GIANSOLDATI, *Department of Physics, Royal Institute of Technology, Stockholm*

Experimental investigations on anti-ferromagnetic alloys

Magnetic and resistometric investigations on gold–manganese alloys with 25, 33.3, and 50 atom per cent Mn show that these alloys have anti-ferromagnetic properties, and give for the first time the opportunity to study the connection between anti-ferromagnetism and the temperature dependence of the electric conductivity. The Néel points for the alloys are −123°C, +90°C, and +227°C, respectively.

ERIC HELLSTRAND, *Department of Physics, Atomic Energy Laboratory, Stockholm*

Preliminary measurements with a pile oscillator at the Swedish reactor

The pile oscillator in use at the Swedish reactor is of the same type as the one used at Harwell. The modulation in the neutron density caused by the oscillation of the sample to be investigated is detected by a boron-coated chamber (TQT-type). After amplification, the signal from the chamber is fed to a sine-cosine potentiometer, driven with the same frequency as the oscillator. The time-dependent voltage from one of the moving contacts of the potentiometer is integrated by means of a velodyne integrator, the result appearing as a number of revolutions counted on a mechanical register.

The oscillator is intended for testing materials, especially for controlling the purity of uranium and graphite. The results of preliminary measurements show that, for uranium test samples of about 500 g weight, differences in absorption cross section corresponding to less than 1 ppm boron equivalence are detectable. No measurements with graphite samples have yet been made.

C. H. HERTZ, *Department of Physics, University of Lund*

A new gas-filled cold cathode amplifier tube

A gas-filled cold cathode amplifier tube has been designed, using a negative point corona in a hydrogen atmosphere as a cathode. The corona current can be controlled by a special electrode arrangement opposite to the point, whereby additional controllable regions of ionization can be established at the anode side of the corona gap. The characteristics of the tube are very similar to those of the vacuum tube. Typical tube data are: point voltage 900 V, grid voltage 40 V, amplification factor 50, inner resistance −100 kΩ, transconductance −0.5 mA/V. The tube can be used as a good voltage stabilizer in a simple circuit, the stabilized voltage being variable to a certain extent.

E. INGELSTAM, *Department of Physics, Royal Institute of Technology, Stockholm*

Present activity at the Institute of Optical Research, especially as regards interferometry

A short review of current work at the Institute (the Laboratory forming part of the Physics Institute of the Royal Institute of Technology) was given, and the subsequent papers were introduced.

A sharing interferometer for the study of path gradients was described, which is under development by Mr. Lars Johansson. Compared with the first measurements utilizing this principle[1] the use of this instrument has been extended by the addition of a compensating device, a rotating polarizer, a Wollaston prism and a photomultiplier set, all acting as a null indicator. It should be possible to measure diffusion constants in very dilute solutions with the same accuracy as is possible with interferometers of conventional design using much larger optical path differences.

E. INGELSTAM, E. DJURLE and B. SJÖGREN, *Department of Physics, Royal Institute of Technology, Stockholm*

Contrast transmission functions for asymmetric images and for the combination of lens and emulsion

It has proven convenient to extend previous designs from this laboratory[2] giving the modern specification of optical imagery in two directions:

1. The scanning of the aerial image formed by the lens should give not only the amplitudes of the line frequencies but also the phases, the latter being important in combining these functions with intensity edges to judge the acuteness of such an edge. This is possible in one of two ways; the most rapid (under development) making use of Lissajou's figures on an oscillograph.
2. The convolution of the image produced by the lens and of the intensity distribution of a narrow slit within the emulsion (due to light diffusion) can be measured with a new apparatus, based on time modulation of the light by a rotating polarizer, in which the amplitude is controlled by a quarterwave plate set at different angles. Results to date have been obtained with Microfile and Panatomic X emulsions. A full description is being printed in the *Journal of the Optical Society of America*, based on a paper by the first author presented at the Symposium on "Problems in the Formation and Evaluation of Optical Images" in Rochester, N.Y., June 15–18, 1955.

C. H. JOHANSSON and HENRIK L. SELBERG, *Nitroglycerin AB, Stockholm*

The ignition mechanism of high explosives[3]

Bowden and collaborators[4] have shown that air inclusions play a great part in the impact sensitivity of high explosives. The conditions for the ignition of the fluid or solid explosive by small gas-bubbles have not, however, been made clear. The increase in temperature of the solid or liquid is only a fraction of the increase in temperature of the air, and if the bubbles are small the duration of the heating will be too small for ignition. This may explain the fact that blasting gelatine, for example, can endure rapid compression to 5000 atmospheres without detonation. The table reproduces some calculated values for temperature of air t_1, temperature of explosive t_s and compression work W_{ad} in adiabatic compression from 1 atm at 20°C to the ratio of volume V_1/V_2 and pressure p. Experimental measurements have given similar results.

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[1] E. INGELSTAM, Arkiv för fysik *9*, 12 (1955).

[2] P. LINDBERG, Optica Acta *1*, 80 (1954).

[3] C. H. JOHANSSON and H. L. SELBERG, Appl. Sci. Res. (in press).

[4] F. P. BOWDEN and A. YOFFE, The Initiation and Growth of Explosion in Liquids and Solids. Univ. Press. Cambridge 1952.

p atm	$\frac{V_1}{V_2}$	t_1 °C	t_s °C	W_{ad} kWs/kg air
2	1.6	83	21	40
5	3.2	190	23	120
50	17	580	45	400
500	100	1 200	180	900
5 000	580	2 280	—	1 800

The sensitivity of the explosive will be considerably greater, if air inclusions of the explosive contain combustion vapours with sufficient vapour pressure. In such a case compressive pressures of 10 to 20 atm are usually quite sufficient to initiate the reaction and give rise to very high temperatures. The combustion heat for ethyl ether vapour in air saturated at 0°C, for example, is approximately twice as great as W_{ad} for compression to 5000 atm. At rapid compression to 15 atm of air with an ether content of 0.1 g/dm^3 the temperature was increased by the heat of combustion from 150°C to 1500°C.

The result will be about the same, if the air inclusions contain small particles or drops of the explosive, or parts jutting out from the surface, or thin layers between neighbouring air bubbles. Particles up to some hundreds of millimetres attain approximately the same temperature as the surrounding air, and considerably larger particles are also ignited much more easily than a great mass with a plane or concave surface. At compression ratios of 20 to 25 and air temperatures of 400°C to 450°C, newsprint paper, cotton and wood filings respectively were ignited and completely consumed. A thin layer of blasting gelatine remained intact on a brass plate but burned on a 0.01 mm sheet of mica. Powder of PETN was ignited at compression to 20 atm, and the temperature was rapidly increased by the heat of combustion from 360°C to 1100°C.

Liquid explosives, which are notorious for being dangerously sensitive, can also sustain great strains without detonating. Thus Bowden and co-workers have reported that a 40 g "cavity striker", falling 5 mm, may initiate a drop of nitroglycerine, while Zippermayr[1] has shot fast bullets (1100 m/s) through canisters of nitroglycerine without detonation. The extremely high sensitivity in the first case can simply be explained on the assumption that small drops are released by the blow and then ignited in the compressed air. If surging at free surfaces and generation of drops are prevented, liquid explosives may be comparatively insensitive to blows.

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[1] M. Zippermayr, Explosivstoffe *3*, 25 (1955).

K.-E. JOHANSSON, *Department of Physics, Chalmers Institute of Technology, Gothenburg*

An investigation of the photoelectric absorption of gamma rays in thallium-activated sodium iodide

The photoelectric absorption of gamma rays in thallium-activated sodium iodide has been determined in the energy range 0.4–1.3 MeV by one absolute and one relative method, through graphical analysis of the pulse height distributions from various isotopes. Corrections were made for electron and K X-ray escape. The measurements were performed with two or more crystals of different sizes in order to make possible an extrapolation to zero crystal extension. In this way the influence of secondary and higher absorption processes could be eliminated, and thus the part of the photons primarily absorbed by the photoelectric effect could be obtained. It was also shown that the same result of the extrapolation was reached with both collimated and uncollimated radiation. According to the absolute method the photoelectric absorption coefficients were calculated with the knowledge of the scattering coefficients from the Klein-Nishina formula. By the relative method isotopes with two or more gamma energies of known relative intensities were used. The pulse height distribution curves were analysed graphically. After the above corrections had been performed the ratio between the photoelectric absorption coefficients for two gamma energies could be calculated. The agreement between the results of the two methods is good. The photoelectric absorption coefficients according to the present investigation are compared with previous theroretical and experimental values.

L. JOHANSSON, *Department of Physics, Royal Institute of Technology, Stockholm*

Microscopic measurement of optical path differences by means of coloured birefringence interferences

The optical path difference produced by the light passing small objects, such as blood-corpuscles or AgBr crystals in photographic emulsions, may be measured by means of a wave-shearing interferometer as originally suggested by Jamin and using a Savart plate according to Françon.[1] In this case, the lateral displacement has to be larger than the image of the object in order that the two images be separated from each other. These two images stand out in different colours in the Newtonean scale on both sides of the coherent background (retardation, and advance, respectively).

The preferable measuring device consists of a turnable wedge, which is set so that the colour of an area bordering the object matches its own colour. Greatest precision is obtained by making this colour match on the region of the Newtonean scale in which the eye is most sensitive to difference in colour.[2]

SVEN A. E. JOHANSSON, *Department of Physics, University of Lund*

Decay scheme of Yb^{169}

The radioactive isotope Yb^{169} decays by K-capture to Tm^{169}. The gamma-radiation following this decay has been investigated by means of a coincidence scintillation spectrometer. Eleven gamma-rays have been found, and the coincidence relations have been investigated in detail. These measurements yield a consistent level scheme for Tm^{169}. Internal conversion coefficients have been calculated. They are used for assigning spin and parity to some of the levels.

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[1] FRANÇON, Rev. d'Optique *31*, 65 (1952).

[2] E. INGELSTAM and L. JOHANSSON, Optica Acta 1955 (in the press).

The level scheme of Tm^{169} is of great interest for a special reason. The spin of the ground state has been measured to be $\frac{1}{2}$. According to the Bohr-Mottelson unified model, nuclei of this type should possess an anomalous rotational spectrum. Hence they are well suited for a detailed test of this model. It now turns out that the level scheme of Tm^{169} is in complete agreement with the predictions of the unified model.

SVEN A. E. JOHANSSON and BENGT FORKMAN, *Department of Physics, University of Lund*

Yield and energy spectra in the photodisintegration of light nuclei

Thin targets of magnesium, aluminium, sulphur and calcium were bombarded with 30 MeV Bremsstrahlung and the yield of photoprotons was determined. This turns out to be several times higher than the yield of photoneutrons from the same elements. This is in agreement with calculations based on the compound nucleus theory. The total yield of protons and neutrons is close to the value predicted by the sum rule of Bethe and Levinger.

A gaseous oxygen target was bombarded with 21 MeV Bremsstrahlung and the energy spectrum of the photoprotons was determined by means of nuclear emulsions. The spectrum is composed of peaks, which shows that the photon absorption goes through narrow resonances. The angular distribution of the protons in a certain peak gives information about the spin of the corresponding level in oxygen. With 26 MeV Bremsstrahlung a similar spectrum was recorded. The number of excited levels is so high in this case that it is difficult to resolve individual peaks. The general trend of the cross section curve can be determined, however.

To investigate the photodisintegration at lower energies, the α-particle spectrum of oxygen was investigated. Nuclear emulsions were soaked in water and bombarded directly in the synchrotron beam. Most of the α-particle tracks are due to the photodisintegration of silver and bromine. There are also some tracks due to the photodisintegration of oxygen. They are characterized by the presence of a short heavy recoil track at the beginning of the α-particle track.

GEORG JONSSON, *Department of Physics, Atomic Energy Laboratory, Stockholm*

The Swedish heavy water reactor. Measurements on the kinetic behaviour of the automatic power control

The automatic power control of the reactor and the measurements made on its response are described. In the measurements a harmonic variation was introduced into the closed control loop, and the response was studied with various feedbacks in the position mechanism for the control plate. An optimal feedback factor was determined. Some measurements were also made on the influence of non-linearities in the loop at large amplitudes, and the results are briefly discussed.

E. KARLSON, *Department of Theoretical Physics, University of Lund*

Radiative corrections to scattering

In a paper which has recently been published[1] the author has shown, without using perturbation theory, that, if charge renormalization is defined in the usual way, the charge operator has the eigenvalue $e(n_- - n_+)$ for a state corresponding to n_- incoming electrons, n_+ incoming positrons, and an arbitrary number of incoming photons. It has also been shown that, in the special case of one incoming electron and no other incoming particles, this leads to the statement that the radiative corrections to the Rutherford formula for the scattering in a weak external field vanish in the non-relativistic limit.

For the scattering of electrons by electrons, the lowest order radiative corrections to the Møller formula have been computed by Redhead.[2] Also in this case the corrections vanish in the non-relativistic limit. An investigation has therefore been started to see if this is true also exactly. It has been shown that the "main term" in the S-matrix in the limit is equal to its lowest approximation. It remains to be shown that the other terms vanish in this limit.

KRISTER KRISTIANSSON, *Department of Physics, University of Lund*

K-particle masses determined photometrically

K-particles have been found in nuclear emulsions exposed in a Sardinian balloon flight in 1953. The masses of the K-particles are determined by comparing the grain density in the K-particle tracks with the grain density in proton tracks. The grain density has been determined by photometric measurements. The mean value of the K-particle masses is $(974 \pm 20) m_e$, in good agreement with measurements in other laboratories.

A. LAGERQVIST and L. HULDT, *Department of Physics, University of Stockholm*

The emitters of the flame spectra of calcium and strontium salts

The well-known fact that the calcium flame is orange-coloured and that of strontium red has been used by the chemists for more than a century as a sensitive indication of the presence of salts of these metals. The spectrum of the calcium flame has two band-groups at about $\lambda = 5500$ Å and $\lambda = 6200$ Å, the strontium spectrum two band-groups at about $\lambda = 6100$ Å and $\lambda = 6900$ Å. For almost a hundred years the emitters of these band-groups have been discussed. Some authors have attributed the radiation to Ca_2 and Sr_2, others to CaO and SrO. Recently, James and Sudgen[3] suggested that the emitters are CaOH and SrOH. In order to decide if this is the case, we introduced deuterium to the strontium flame.[4] We then found new band-heads in the spectrum, which shows that the emitter contains hydrogen. Thus the actual band-groups may probably be attributed to SrOH. By similar investigations Gaydon[5] has now obtained the corresponding result for the calcium band-groups.

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[1] E. KARLSON, Proc. Roy. Soc. A *230*, 382 (1955).

[2] M. L. G. REDHEAD, Proc. Roy. Soc. A *220*, 219 (1953).

[3] C. G. JAMES and T. M. SUDGEN, Nature *175*, 333 (1955).

[4] A. LAGERQVIST and L. HULDT, Naturwissenschaften *42*, 365 (1955).

[5] A. G. GAYDON, Proc. Roy. Soc. *231*, 437 (1955).

GÖRAN LEIDE, *Department of Physics, University of Lund*

Fading and ionization measurements in Ilford G5 emulsions

Nuclear emulsions were exposed to high energy protons on several occasions within two months. During this time they were kept at different, constant conditions. After development tracks from the exposures were measured by a photoelectric method.

Fading was studied at 3–30°C, 15–75 per cent relative humidity and 3–100 keV/μ ionization. The effect may be a possible and, in some cases, severe source of error in mass determinations by range-grain density methods, if the plates are exposed to relative humidities over 50 per cent and to temperatures over 15–20°C. At 75 per cent relative humidity 25°C a proton track may look like a χ-meson track after about 3 days. Fading is more pronounced near the surface, but is constant in the rest of the emulsion. The relative reduction of mean track width is more pronounced at low ionization and at underdevelopment.

INGVAR LINDGREN, *Department of Physics, University of Uppsala*

Magnetic moments of radioactive nuclei by an atomic beam focusing method

An atomic beam magnetic resonance apparatus for the measurements of the spins of the nuclei and the hyperfine splitting of radioactive isotopes, similar to the apparatus built in Princeton by Lemonick and Pipkin,[1] is just being constructed in Uppsala. As A and B deflecting magnets,[2] focusing six-pole magnets are used, which also gives a compensation for the aberration caused by the Maxwellian distribution of the velocities in the beam. This arrangement gives a much greater luminosity than is obtained by the conventional method and therefore makes it possible to investigate radioactive isotopes. We calculate to use an effective solid angle of about $2 \cdot 10^{-5} \times 4\pi$ steradians for $^2S_{\frac{1}{2}}$ atoms, and a temperature of 1000°K in the oven.

As detector a plate is to be used, upon which the atoms are collected for a few minutes. The intensity is then measured with a 2π Geiger counter.

At very weak field in the C magnet (Zeeman region), the resonance frequency gives the spin of the nuclei. At stronger field (intermediate coupling) it gives with the Breit-Rabi formula the hyperfine splitting.[2, 3] An approximative value of the magnetic moment can then be calculated with the Goudsmit-Fermi-Segré formula.[4]

E. RUNE LINDGREN, *Department of Mechanics, Royal Institute of Technology, Stockholm*

Properties of certain bentonite suspensions and water. A note on the inadequate definition of the Reynolds number in hydrodynamics

In classical rheology a distinction is made between *Newtonian* and *non-Newtonian* liquids. It is assumed that the Newtonian liquids do possess definite viscosity values independent of shear stress and depending on the temperature only, while the viscosity of a non-Newtonian liquid decreases to a lowest possible definite value $\nu = \nu_\infty$ when the shear stress in the liquid increases and exceeds a certain yield value.

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[1] A. LEMONICK and F. PIPKIN, Phys. Rev. *95*, 1356 (1954).

[2] J. B. M. KELLOGG and S. MILLMAN, Rev. Mod. Phys. *18*, 323 (1946).

[3] N. F. RAMSEY: Nuclear Moments. Wiley & Sons, Inc., New York.

[4] H. KOPFERMANN: Kernmomente. Akad. Verlagsges. m. b. H., Leipzig 1940.

Modern rheologists however have called in question the existence of any Newtonian liquids at all, as well as the existence of any definite ν values. The *coefficient of viscosity has actually proven not to be a true physical constant.* This quantity depends not only on the temperature but also on the conditions of flow. Particularly water is known to exhibit pronounced structural properties.

Experiments are reported here which concern the viscosity of certain bentonite sols as well as of water.

The kinematic viscosity $\nu = \nu_\infty$ of the suspensions, under the influence of high rates of shear exceeding the yield values, has been found to be approximatively an exponential function of the bentonite concentration γ, according to the formula

$$\nu(\gamma, t) = \nu_0(t) \cdot 10^{k\gamma}$$

where $\nu_0(t)$ is the kinematic viscosity of water at the temperature t, and k is an empirical constant $k = 0.0314$ when γ is expressed in ‰.

The measurements have shown that the bentonite sols do exhibit non-Newtonian behaviour, in its classical meaning, at all concentrations. Also pure water has proven to exhibit structural properties.

Furthermore a preliminary evaluation of some measurements, which will be reported in full later on, shows that the ν values of both water and bentonite sols, as given above, are not constant but depend on the conditions of flow. This is a direct hydrodynamic experimental verification of experiences reported by advanced rheologists.

The statements above imply that *the Reynolds number, as hitherto defined in hydrodynamics, is no adequate quantity in describing flow phenomena.* It must be replaced by a proper dimensionless combination of variables, unknown at the present time.

STEN LJUNGBERG, *Nitroglycerin A.B., Stockholm*

Initiation in the falling weight test

The aim of the present investigation has been to study the initiation of an explosion in falling weight tests. A modified falling weight apparatus, in which a set suspended body of the same shape and weight as the falling weight serves as an anvil, has been employed. The apparatus needs no foundation, and the course of the impact is simpler and clearer from a theoretical point of view. In addition roller-bearing rollers with a diameter of 8.00 mm and a length of 12 mm were used as stamps. The plane surfaces of the rollers facing the explosive were either polished or ground with concentric scratches. The sleeve of the stamp was constructed with cylindrical borings 8.00 or 8.05 mm in diameter, or with a ring-shaped turned cavity facing the layer of explosive with ample room for the explosive. The tests reported here refer to the last-mentioned case.

The compression/time process at the impact was registered with a cathode ray oscillograph with the help of a strain gauge on a roller-bearing roller between the anvil and the stamp. With the help of a photoelectric cell directed towards the layer of explosive through a hole in the sleeve it was possible to register the moment of detonation simultaneously on the screen.

A couple of steel cylinders 50 mm in diameter and impact surfaces of 8 mm diameter (type I) and also a pair of 8 mm steel rods with an impact surface over the entire plane surface (type II) were used as falling weight and anvil. The compression/time curve is sinusoidal in type I, and rectangular in type II. In the latter the impact time could be varied by changing the length of the rods.

In falling weight tests with plastic explosives, e.g. blasting gelatine, a radial flow takes place without a measurable increase in pressure. When the thickness of the layer has fallen below 0.1 mm there is a small increase in pressure which lasts about 30 μs. The main part of the remaining layer during that time is pressed out until metallic contact is achieved between the surfaces. The pressure process then becomes approximately as in impact without any layer of explosive.

In falling weight tests of type I with blasting gelatine between polished surfaces, no detonation was obtained at drops up to 1.2 m. Between surfaces with concentric scratches detonation was achieved down to a drop of 0.2 m. Hot spots may be obtained by plastic deformation of ridges and tops which ignite the remains of the explosive layer left lying in the scratches, when the impact surfaces begin to get direct contact and the pressure rises. The photoelectric cell has in these cases registered detonations after 30–45 μs from the beginning of the impact. The detonations are indicated by rapid, brief rises in pressure in the upward part of the sinusoidal curve, but often they cannot be distinguished from incidental variations.

With the falling weight of type II and with concentric scratches, the detonation is indicated by a definite peak in the registered curve. With a striking speed of 5.4 m/s (a drop of 1.5 m) it takes 60 μs before the outflow is completed and detonation achieved. If a layer which has not detonated is exposed to a renewed blow the detonation occurs immediately, superfluous explosive having already been discharged in the previous stroke. The same result is obtained if the layer is exposed to static pressure in a press before the stroke. If the striking speed is lowered to 4.5 m/s the impact is terminated and the pressure has disappeared when the detonation occurs. This is rendered possible by a certain interval of time between the beginning of the decomposing reaction and the explosion.

A. Lodding, *Department of Physics, Chalmers Institute of Technology, Gothenburg*

A temperature effect in connection with isotope-separation by passage of electric current through molten metal

The so-called Haeffner effect was investigated in molten indium metal at two different temperatures, 200°C and 500°C approximately. In both cases the apparatus consisted in principle of a Pyrex-glass capillary, about 40 cm long and of 0.5 mm inner diameter. Tungsten wires of diameter 0.5 mm, fused into each end of the capillary, served as electrodes. An electrolyzing current with a density of approx. 3500 A/cm^2 was allowed to pass through the molten metal in the capillary for about a month. The capillary was then cut up in ten pieces of about equal length. The solidified indium in each piece was converted into $InCl_3$ and analysed in a mass spectrometer at the Atomic Energy Laboratory in Stockholm. For both temperatures an enrichment of the light isotope In^{113} was discovered at the anode. The mass effect was $\mu \approx 1 \times 10^{-5}$ for the 200°C experiment and $\mu \approx 2.5 \times 10^{-5}$ for the 500°C experiment. Temperature thus appears to have a marked influence on the Haeffner effect in indium.

L. LUNDBERG, *Research Institute of National Defence, Stockholm*

Some investigations with X-ray flash and Kerr cell shutter camera

These instruments are useful in the study of rapid events. Pictures were shown at the meeting, illustrating the detonation process, pressure waves in metals, "scabbing" of metals and deformation of objects exposed to strong blows. Two further applications should be mentioned. These are, first, the possibility of measuring the density of materials at very high pressures (≈ 0.5 Mb) and second, a way of determining the time delay before ignition, when a piece of high explosive is hit by a blow.

A. LUNDÉN, *Department of Physics, Chalmers Institute of Technology, Gothenburg*

Isotope enrichment by counter-current electromigration in molten nitrates

In earlier experiments with isotope enrichment by electrolysis of molten halides it was found that the mass effect, μ—defined as the relative difference in velocity divided by the relative difference in mass—always followed a rule set up by Klemm:

$$\mu = -0.15\left(1 + \frac{m^+}{2.1\ m^-}\right)^{-1}$$

where m^+ and m^- are the masses of the positive and the negative ion. In order to investigate if this rule holds also for salts other than halides the mass effect for potassium in molten KNO_3 was measured by Lundén, Reutersward and Sjöberg.[1] The result $\mu = -0.036$ did not agree with Klemm's rule. We have now measured the effect for lithium in molten $LiNO_3$ and found $\mu = -0.055$, which confirms that the nitrates do not follow the same rule as the halides. The mass effects for KNO_3 and $LiNO_3$ can be summarized by the formula

$$\mu = -0.062\left(1 + \frac{m^+}{54}\right)^{-1}$$

A full account of the work with $LiNO_3$ is being published elsewhere.[2]

STIG O. LUNDQVIST, *Department of Theoretical Physics, University of Uppsala*

On the residual ray frequencies of cubic ionic crystals

The vibrations of a cubic ionic lattice are investigated using a potential which is a first approximation of the expression for the cohesive energy according to the Heitler-London method. Besides ordinary two-particle interactions this potential contains a term representing a three-body interaction. The main effect of this term is the introduction of an effective ionic charge, a concept which has earlier been introduced empirically. Neglecting the optical polarisation, the residual ray frequency can be expressed in terms of the three elastic constants of the crystal. By expressing the total polarisation in terms of the dielectric constants for static and high-frequency fields a more accurate formula for the residual ray frequency has been derived, which is a generalisation of that given by Szigeti for the case of central forces.

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[1] A. LUNDÉN, C. REUTERSWÄRD & N.-G. SJÖBERG, Z. Naturforschg. *10a*, 279 (1955).

[2] A. LUNDÉN, E. U. MONSE and N. G. SJÖBERG, Z. Naturforschg. (in preparation).

P. O. Löwdin, *Quantum Chemistry Group, Department of Chemistry, University of Uppsala*

The correlation energy in solids

In the quantum theory of the electronic structure of solids based on the orbital picture, the question of the treatment of the correlation effects depending on the mutual interaction between the electrons has always been a crucial problem. It seems as if the classical formulation of the Pauli principle permitting two electrons in the same orbital would be the main source for the trouble. If two electrons having opposite spins are forced together in space by placing them in the same orbital, one can certainly expect a comparatively large "correlation error" to occur because of their mutual Coulomb repulsion. An analysis of the results of some recent calculations on atoms and molecules has now shown that "the correlation energy per doubly filled orbital" seems to be remarkably constant and rather independent of the form of the orbital; the order of magnitude is 1.0–1.2 eV, except for orbitals highly concentrated in space, where it may rise to higher values. Some data for the He-like ions and for two molecules are listed in Tables I and II, respectively.

Correlation error in eV per doubly filled orbital

Table I

H^-	1.22	Be^{+2}	1.26
He	1.15	B^{+3}	1.36
Li^+	1.20	C^{+4}	1.54

Table II

H_2	1.06
C_6H_6	≈ 1.0

The good results for the cohesive energy of the ionic crystals obtained previously by the orbital picture[1] strongly support the idea that the correlation energy per doubly filled orbital is fairly constant, since the correlation error is then cancelled in subtracting the energy of the free ions from the total energy of the crystal. The constancy of the correlation error explains also why it is possible to obtain such good results for e.g. the elastic constants by using a simple wave function based on the orbital idea (see the following communication).

There seems to be a remarkable exception from the constancy rule for the correlation error. The electronic correlation in the alkali metals has been studied by Wigner,[2] and, by using his formula, we obtain the following correlation energies in eV per doubly filled valence orbital:

Table III

Li	1.89
Na	1.73
K	1.58

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[1] See e.g. P. O. Löwdin, A Theoretical Investigation into Some Properties of Ionic Crystals. Almqvist & Wiksell, Uppsala, 1948.

[2] E. Wigner, Phys. Rev. *46*, 1002 (1934); Trans. Far. Soc. *34*, 678 (1938); Proc. Int. Conf. Theor. Phys. Japan 1953, p. 649.

i.e. data considerably higher and more varying than those listed in Tables I and II. Wigner's results, which recently have been confirmed by the plasma model,[1] have been successfully used in determining the cohesive properties of the alkali metals by orbital theories of a more or less semi-empirical character.[2, 3] However, considering the discrepancy between the values in III and those given in I and II, we have found it worth while to try to reexamine the question of the correlation effects in the alkali metals. Using the idea of "static correlation"[4] and the method of "alternant crystal orbitals",[5] we are now trying to recompute the cohesive energies of some of the alkali metals. We expect[6] that the "alternant effect" should account for about 80 per cent of the correlation energy, whereas the atomic "ion-out" effect may give another 10 per cent. It is necessary to evaluate a large number of atomic integrals, but the numerical computations are now in progress.

P. O. LÖWDIN, *Quantum Chemistry Group, Institute of Chemistry, University of Uppsala*

The many-body potential and the elastic constants of the alkali halides

For the three elastic constants c_{11}, c_{12}, and c_{44} of the alkali halides, it has been theoretically shown[7] by quantum mechanics that the classical Cauchy relation $c_{12} = c_{44}$ is not valid because of the occurrence of a many-body potential depending on the overlapping between the ions. The difference $c_{44} - c_{12}$ is experimentally found to be large for crystals like LiF and NaCl, but very small for KCl, and this fact makes it likely that the many-body potential may vanish when the positive and negative ions tend to be of about the same size. A theoretical proof of this theorem was given by Lundqvist[8] in the S^2 approximation, but he also pointed out that, for the large overlapping occurring when the two ions have about the same extension, it was doubtful whether this approximation is strictly valid.

An improved technique for evaluating the three- and four-centre integrals in the many-body potential was developed by the author,[9] who used two parameters, λ_1 and λ_2 subject to the condition $\lambda_1 + \lambda_2 = 1$, for the description of the difference in extension of space of the two ions. In connection with the Japanese Conference in 1953, it was further shown[10] that, in the special case $\lambda_1 = \lambda_2 = \frac{1}{2}$, the many-body potential is actually vanishing to an excellent degree of approximation.

In the previous calculations of the elastic constants,[7] the electron orbitals of the negative ion were developed in spherical harmonics at the centre of the positive ion and then the "inner parts" of these expansions were actually taken into account (method *a*); this technique was slightly improved by Lundqvist[8] by moving the expansion centre to the "centre of gravity" of the two ions (method b). By using also the "outer parts" of the expansions one could, of course, have obtained a much more reliable result independent of the expansion centre. The elastic constants have now been recomputed by using the λ-technique and the complete expansions (method c), and the values of the relative difference $(c_{44}-c_{12}):(c_{44}+c_{12})/2$ are listed below:

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[1] D. PINES, Phys. Rev. *92*, 626 (1953); Proc. 10th Solvay Conf. 1954 (in press).

[2] E. WIGNER and F. SEITZ, Phys. Rev. *43*, 804 (1933); *46*, 509 (1934).

[3] J. H. VAN VLECK, Proc. Int. Conf. Theor. Phys. Japan 1953, p. 640; H. BROOKS, Phys. Rev. *91*, 1027 (1953).

[4] P. O. LÖWDIN, Adv. Physics *5*, 1 (1956) (in press).

[5] P. O. LÖWDIN, Nikko Symp. Mol. Phys. 1953, p. 13; Proc. 10th Solvay Conf. 1954 (in press); Phys. Rev. *97*, 1509 (1955).

[6] Cf. the results by T. ITOH and H. YOSHIZUMI, J. Phys. Soc. Japan *10*, 201 (1955); J. Chem. Phys. *23*, 412 (1955).

[7] P. O. LÖWDIN, A Theoretical Investigation into Some Properties of Ionic Crystals. Almqvist & Wiksell, Uppsala, 1948; Arkiv mat., astr. o. fysik *35A*, No. 30 (1948).

[8] S. O. LUNDQVIST, Arkiv Fysik *6*, 25 (1952).

[9] P. O. LÖWDIN, J. Chem. Phys. *21*, 374 (1953).

[10] P. O. LÖWDIN, Proc. Int. Conf. Theor. Phys. Japan 1953, p. 599.

Crystal	Theoretical method			Experimental value
	a	b	c	
LiF	0.41	—	0.31	0.31[1]
NaCl	0.43	0.38	0.28	0.20;[2] 0.28[3]
KCl	0.45	—	0.16	0.11[2]

For LiF and NaCl, the results are therefore now brought in fairly good agreement with the experimental values, but, for KCl, there is still a small discrepancy to be explained.

CURT MILEIKOWSKY and KATARINA AHNLUND, *Nobel Institute of Physics, Stockholm*

Investigations of energy levels of light nuclei

In recent years there has been considerable activity at several laboratories in order to determine the positions of the energy levels of the light nuclei. To the largest extent results have been obtained by magnetic analysis of particle groups from nuclear reactions. During this work, very many new levels have been found, and in some cases levels earlier considered as single have been shown to be composed of several closely-spaced ones.

It follows, naturally, that interest is focused on the determination of the other characteristic nuclear properties of these nuclear states, spin, parity and isotopic spin values. One of the most powerful methods is the investigation of angular distributions of particle emission following nuclear reactions. At the High Voltage Laboratory we have recently, in parallell with measurements of the first kind, changed the experimental arrangements in order to be able also to measure angular distributions. Our solution of the monitoring problem is to let the heavy particle spectrometer swing, with some minutes' interval, between two angles of which one is a reference angle. This is accomplished by an automatic device, working under vacuum and high voltage. The practical realization of this are discussed and some results from recent measurements shown.

NANNY NILSSON, *Department of Theoretical Physics, University of Uppsala*

The contribution of the diffuse scattering to the measured intensity of a Bragg reflection

The general expression for the intensity of the diffuse temperature scattering of X-rays by crystals obtained from Waller's theory is taken as the starting-point in deriving a formula for the integrated intensity of the diffuse maxima, coinciding with the Bragg maxima. Numerical calculations, corresponding to the experiments made by James and Brindley with KCl crystal and by Renninger with NaCl crystal, show that the effect of the diffuse scattering for the highest reflections amounts to 30 per cent of the integrated Bragg reflections. Thus the diffuse scattering is essential in measurements of the integrated reflections performed with single crystals.

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[1] H. B. HUNTINGTON, Phys. Rev. *72*, 321 (1947), at room temperature.

[2] M. A. DURAND, Phys. Rev. *50*, 449 (1936), at low temperature.

[3] OVERTON and SWIM, Phys. Rev. *84*, 758 (1951), at $T = 0$.

S. BERTIL NILSSON, *Department of Theoretical Physics, University of Lund*

On the Coulomb effect for internal bremsstrahlung

In a β-decay there is a certain probability for the emitted electron to be accompanied by a photon (internal bremsstrahlung). For comparison with the experimental photon yield it is usual to apply a theoretical formula obtained by the following procedure. (a) The transition rate is computed in Born's approximation, which neglects the influence of the nuclear charge. The ensuing expression contains a factor identified as the probability spectrum of an ordinary β-decay for zero charge. (b) The influence of the electrostatic nuclear field is taken into account by substituting the β-spectrum corrected for the Coulomb effect.

To see what happens in a more consistent theoretical treatment, the calculation was repeated in such a way that the presence of the Coulomb field was considered from the beginning and not just in the end result (assuming an allowed transition). So far, however, the calculation is preliminary in considering only that part of the Coulomb effect which has to do with the proper β-transition. A numerical integration in the case of S^{35} shows a marked increase over the photon yield predicted by the older formula. However, this increase is not, in the present approximation at least, large enough to account for the very high yield observed in recent experimental work.[1]

S. G. NILSSON, *Department of Theoretical Physics, University of Lund*

Particle states in strongly deformed nuclei

For nuclei with very large deformations, the so-called strong coupling scheme suggested by Bohr and Mottelson is applicable, and it is possible to make an approximate separation between intrinsic nucleonic motion relative to the deformed nuclear field, considered as stationary, and the collective rotational and vibrational motion.

The aim of this work was to study the intrinsic mode of motion. To represent the interaction of one nucleon with the nuclear field, a non-isotropic oscillator potential + a spin-orbit term is assumed.

To this is further added an l^{-2} term representing a correction for the too fast rising of the oscillator walls. The parameters of the potential are chosen so as to reproduce the shell model levels near magic numbers, i.e. for approximately spherical nuclei.

Eigenvalues and eigenfunctions of this potential have been calculated as functions of the parameter of deformation.

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[1] N. STARFELT and N. L. SVANTESSON, Phys. Rev. *97*, 708 (1955), *q.v.* for further references. A fuller account of the present work will appear in Arkiv för Fysik.

Empirical ground state spins of odd-A nuclei in the region $150 < A < 194$ (one region where the "strong coupling" scheme is expected to be applicable) have been compared with predictions of the model. The agreement is remarkably good.

Also the equilibrium deformation has been studied in this region. The sign and magnitude of deformation seems to be in agreement with what is deduced from the empirically measured electric quadrupole moments.

An analysis of electromagnetic transitions and magnetic moments in terms of the calculated wave functions is in progress.

BERTIL NORDFORS, *Department of Physics, University of Uppsala*

The Al $K\alpha_3$ α_4 lines in metal and oxide

Using a large bent crystal vacuum spectrometer the satellite lines α_3 and α_4 in the K spectrum of aluminium were recorded in metal and oxide. The registrations were made with a Geiger counter. An interesting change in intensity and line shape of these lines in oxide as compared to metal is reported and discussed.

A. PERSSON, *Nitroglycerin AB., Stockholm*

Experimental determination of temperature conditions in rapid compression of air

In tests with rapid compression of gases, which have been carried out by Tizard and Pye,[1] Jost,[2] Bowden[3] and others, the temperature in the compressed gas has been calculated using the equation

$$T = T_0\,(V_0/V)^{\gamma-1}. \tag{1}$$

T_0 is the initial temperature, V_0/V the volume ratio and γ a polytrophic exponent, which is obtained from the equation

$$p/p_0 = (V_0/V)^{\gamma} \tag{2}$$

in which p_0 is the initial pressure. γ is mostly assumed to be 1.4, i.e. the compression is assumed to take place adiabatically. Tizard and Pye registered the pressure, but it is generally considered sufficient to determine the volume conditions.

In this investigation the volume and pressure conditions have been registered. The temperature can then be calculated according to the general equation of state for ideal gases

$$T = \frac{pV}{nR}. \tag{3}$$

n is the number of gramme molecules and R the gas constant. A prerequisite is that n is constant, i.e. that the compression takes place without leakage. Equation (1) with $\gamma = 1.4$ gives an upper limit for the temperature which can be attained.

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[1] H. T. TIZARD and D. R. PYE, Phil. Mag. *44*, No. 259, July 1922.

[2] W. JOST and H. TEICHMANN, Naturwiss. *27*, 318 (1939).

[3] F. O. BOWDEN and A. P. YOFFE: Ignition and Growth of Explosion in Liquids and Solids. University Press, Cambridge 1952.

The tests were carried out with a thick-walled steel compression cylinder with an internal diameter of 26 mm. The piston is fitted with a Bridgman packing. The bottom of the cylinder is a brass membrane. A system of coils, the induction of which depends on the curve of the membrane is placed close to the membrane. The pressure is directly proportional to the mutual induction which is registered on a cathode ray oscillograph. The volume–time curve is registered with a potentiometer, the sliding contact of which follows the movement of the piston rod.[1]

Some of the results of the tests are given in the following table. The table shows volumes and compression times and the maximum temperature calculated according to (3), compared with the temperature at adiabatic compression, and the energy added in the compression in kWs/kg of air, compared with the energy required at adiabatic compression.

Ratio of volume	Compr. time s	Final volume cm^3	Initial temp. °C	Max. pressure kp/cm^2	Max. temp. °C	Max. temp. at adiab. compr. °C	Compr. work kWs/kg	
							Adiab.	$\int p\,dV$
2.87	0.029	14.2	25	4.13	159	182	109	107
6.8	0.034	5.95	25	13.8	332	364	240	246
15.4	0.210	6.87	20	36	412	600	397	335
20.4	0.210	5.20	20	50	435	699	476	459
25.9	0.260	4.1	20	65	463	802	534	462

The above tests were made in connection with an investigation of the importance of air and gas inclusions in the initiation of explosives by compression.

A. PRAMBERG, *Research Institute of National Defence, Stockholm*

Phosphate glass dosimetry for γ-rays

Permanent fluorescense centres are obtained in a silver activated phosphate glass exposed to γ-rays. When irradiated with long wavelength UV-light it emits fluorescense light proportional to the dose received. A dose meter for 20 to 1000 roentgens has been constructed. The dose reading instrument is directly calibrated in roentgens. A stabilizing circuit, which forms part of the electronic circuit, makes use of two photocells and serves the purpose of stabilizing the reading against changes in the UV-source and in the mains.

CARL REUTERSWÄRD, *Department of Physics, University of Uppsala*

On the isotopic abundances in potassium

The isotopic composition of K has been investigated with the object of inquiring into the discrepancies between earlier mass spectrometer work employing ion sources of different types. Thermal surface ionization sources and a simple magnetic analyser of the 180° type were used. Experiments in which the isotopic ion currents were time-integrated show different behaviour of thin and thick emitting salt layers. The measurements on very thin layers give a mass discrimination fairly equivalent to that of molecular effusion, and also isotopic abundance ratios consistent with the recent ones of Nier (1950). On taking the initial ratios of ash from pacific kelp, the strange results of Brewer (1936) are, in a way, corroborated. The significance of this fact has been analysed.

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[1] N. L. GREENOUGH and W. E. WILLIAMS. Journ. of Res. Nat. Bur. Stand. *46*, No. 1, Jan. 1951. The instrument employed in this investigation was designed and manufactured at the Research Inst. of National Defence, Stockholm.

ARNE ELD SANDSTRÖM, *Department of Physics, University of Uppsala*

Experimental evidence of the direction of the components of primary cosmic radiation

Cosmic ray data for 700 days, collected[1] in Stockholm 1947–50, have been analysed[2] as to the correlation between geomagnetic activity and the diurnal variation. The results of this study have now been treated in an attempt to ascertain the existence of directional components in cosmic radiation. For this purpose a correction was applied for the deviation of the primaries in the Earth's magnetic field.[3] Thereafter the diurnal variation of the cosmic rays can be resolved into two components represented by the coefficients of its first harmonic.

One of these two components has its maximum at 18^h, the second at 12^h. The first one appears to be constant both as a function of geomagnetic activity and as a function of time. There is, however, a doubtful indication of disturbances in connection with major magnetic storms. The 12^h-component evidently varies in a continuous way with geomagnetic activity and with time. The two variations are independent.

The 18^h-component corresponds to a particle wind bound to the motion of the Sun and predicted[4] in the theory by Alfvén. The 12^h-component represents the sum of a radial particle flow and the general diffusion, outwards or inwards, of particles.

It has been possible to compare the Stockholm results with measurements[5] made in Nagoya and in Huancayo. The Stockholm measurements had been made in three directions, which makes it possible to determine the time correction. This becomes difficult, in many cases impossible, when measurements have been made in one direction only as in Nagoya and Huancayo. Nevertheless, it was possible to show that an analysis of the registrations from these two places yields results corroborating those from Stockholm. A full account will be published in *Tellus*.

M. SCHMORAK, R. STOCKENDAL, H. ATTERLING, I. BERGSTRÖM and J. A. MC DONELL, *Nobel Institute of Physics, Stockholm*

The decay of Bi^{203}, Bi^{204} and Bi^{205}

A. Bi^{205}.

Bismuth activities were produced by bombarding lead in the Nobel institute cyclotron with 25 MeV deuterons. (d, x, n)-reactions on Pb^{206}, Pb^{207}, Pb^{208} are expected to produce Bi^{207} (50 y), Bi^{206} (6.4 d), Bi^{205} (14.5 d) activities.

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[1] MALMFORS, Tellus *1*, 55 (1949).
[2] SANDSTRÖM, Tellus *7*, 204 (1955).
[3] BRUNBERG and DATTNER, Tellus *6*, 254 (1954).
[4] H. ALFVÉN, Tellus *6*, 232 (1954).
[5] SEKIDO and KODAMA, Rep. of Ionosph. Research in Japan *6*, No. 2.

The Bi activity was separated chemically from the lead target and electroplated on a 2 × 15 mm copper foil. For the purpose of studying the Bi^{205} isotope, the source was allowed to stand for a few weeks in order to increase the Bi^{205}/Bi^{206} ratio, then measurements were made with the Nobel Institute double focusing spectrometer. As the source proved to be rather thick, the measurements were made mainly in the high energy region of 700–2000 keV. In this region two complete runs were made, using 3.5 per cent resolution. In the 180–700 keV region only one run was made. For energy calibration the following lines were used, all values in keV: K 569.7, and K 1063.9 of Bi^{207} and K 661 of Cs^{137}.

The following lines were identified as Bi^{205} lines.

γ-energy keV	260	267	282	349	382	493	510	530	550	579	
K-intensity	3 400	260	3 700	1 000	200	260	650	200	240	900	
γ-energy keV	625	687	703.3	745.0	758.3	761.0	911.1	987.5	1 002.7	1 014.2	
K-intensity	340	120	3 700	100	220		365	990	90	400	
γ-energy keV	1 043.7	1 190.3	1 337	1 351.5	1 502.5	1 552.0	1 615.6	1 766.4	1 777.4	1 863.3	1 906.5
K-intensity	1 260	280	8	50	20	40	113	1 620	180	70	25

The intensity figures represent actual counts per minute, obtained at a time of 3 half-lives after the bombardment. In addition a line at 2.6 Mev was found with a scintillation spectrometer, and a number of lines were found below 180 keV (in a permanent magnet spectrometer) but were not identified yet. The energies of the lines in the 700–2000 keV region checked in the two complete runs to 1:10^3 and better.

Positrons were found with max. energy of 1 MeV.

The strongest Bi^{206} lines were also found by us, and their energies check with those found by Alburger,[1] to better than 1 part in 10^3.

A search was made for an isomeric transition[2] in Pb^{205}, but no such transition was found. e–γ coincidence experiments are in progress, and e–e coincidence work is being planned.

B. Bi^{203} and Bi^{204}.

These neutron-deficient isotopes were produced by (p, x, n)-reactions in the Uppsala synchrocyclotron from lead. Several bombardments were made around 50 MeV. Besides Bi^{203} and Bi^{204}, also Bi^{205}, Bi^{206} and Bi^{207} activities were produced. A permanent magnet 180° spectrometer and a double focussing spectrometer were used to study the conversion lines. It was not possible yet to differentiate between Bi^{203} and Bi^{204} lines, because their half-lives are nearly the same. A preliminary estimate gives

$$(Bi^{204}) = (13.5 \pm 0.7)\ \text{h},\ (Bi^{203}) = (12.3 \pm 0.7)\ \text{h}.$$

At least 30 γ-rays are present in the combined decays of these two isotopes.

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[1] ALBURGER and PRYCE, Phys. Rev. *95*, 1482 (1954).

[2] STOCKENDAL *et al.* Physics Conference 1955, see communication below.

MIROSLAV SEDLAČEK[1], *Department of Electronics, Royal Institute of Technology, Stockholm*

Microtron-injector for the 1000 MeV electron synchrotron

In the microtron one makes use of a uniform magnetic field and a cavity resonator fed by microwave power to accelerate electrons. A stable acceleration can be attained in the case when the electrons starting from rest gain an energy of 511 keV at each gap transit. This corresponds to the rest-mass energy. It was pointed out by Henderson, Heymann and Jannings that the curve which represents the positions of electrons starting from rest in the phase coordinates lies outside the phase-stable region, after the first gap transit. By decreasing the resonant magnetic field 2 to 4 per cent it can be achieved that some of the electrons starting from rest lie inside the phase-stable region. Under these circumstances, however, the number of electrons which are stably accelerated is very small. It amounts to about 1 per cent of all the electrons crossing the gap at the first transit. The beam current and the efficiency of the machine are low. In the case when the electrons are injected into the gap with an energy of 60–70 keV all the electrons in a phase angle of some 25° are stably accelerated. The last can be accomplished by using an electron gun of a convenient shape, which will not disturb the electrons at their first revolution.

H. L. SELBERG, *Nitroglycerin AB, Stockholm*

Theoretical investigation of the initiation of nitroglycerine by shock waves

It is assumed that the reaction in stable detonation is initiated by a shock wave, which is propagated with the velocity of the detonation and has a front coinciding with that of the reaction zone. For nitroglycerine S. Ratner has made a calculation of pressure, velocity and temperature in the shock wave front on the basis of an extrapolated equation of state and determined the pressure at 500 000 atm., the velocity at 4000 m/s and the temperature at 3000°C. Ratner[2] adopts the following equation of state for the nitroglycerine

$$p = a\,\varrho T + b\,\varrho^4 - f\varrho^3$$

in which p is the pressure, ϱ the density and T the temperature (°K).

If it is a question of initiation by more moderate shock waves it should be possible to arrive at more reliable results. Thermodynamic data for nitroglycerine are not published, but it is fairly obvious that nitroglycerine can be compared with some other liquid, taking into account the fact that different liquids behave in essentially the same manner as far as compressibility is concerned. The propagation of shock waves in water has been investigated by Kirkwood[3] and collaborator. Table 1 shows the connection between velocity of flow u, velocity of propagation U, increase in temperature ΔT, pressure p and increase in internal energy ΔE.

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[1] On leave from the Institute Ruder Bošković, Zagreb.

[2] S. RATNER, "On the detonation mechanism of liquid explosives." Acta Physicochim. U.R.S.S. *22*, No. 2.

[3] R. H. COLE, Underwater Explosions. 1948, p. 40.

Table 1

u m/s	U m/s	p atm	ΔT°C	$\Delta E = {}^1/_2\, u^2$ kWs/kg	Residual increase of temperature after passage of the wave (°C)
426	2 330	10 000	36	92	
689	2 880	20 000	69	238	
1 075	3 700	40 000	127	578	about 40
1 235	4 000	50 000	152	763	55
1 510	4 610	70 000	190 (extra-polated)	1 140	85

The corresponding table for nitroglycerine is

Table 2

u m/s	ΔT°C
426	90
689	170
1 075	320
1 235	380

The increase of temperature after the shock wave has passed will probably amount to about 200°C for $u = 1500$ m/s.

If we assume that nitroglycerine explodes at about 500°K it then follows that a shock wave in a pure liquid and airfree nitroglycerine of ordinary temperature and density cannot produce a sufficiently high temperature for initation, if the velocity of flow is less than 800 m/s. And, even then, the shock wave must be of some duration. First, it takes some time for the explosive to decompose, and second, it takes some time for the reactions to be completed. It seems probable that, in practice, initiation by shock wave is only possible if the remaining increase of temperature is sufficient for initiation. The velocity u must in that case amount to at least 1500 m/s.

MAX SETTERWALL, *Research Institute of National Defence, Stockholm*

A method for the compensation of Compton contributions in γ-scintillation spectra

It is well known that the Compton distributions in scintillation spectra obtained with Na J (Tl) can be compensated for by the subtraction of the corresponding Compton distributions obtained from a measurement with an anthracene crystal. This subtraction has been carried out automatically by D. H. Peirson.[1] His circuit utilizes a sweeping single-channel analyzer, a modified rate-meter and a recorder. The two detectors are connected alternatively to the pulse-analyzer input for time intervals short compared with the time constant of the rate-meter tank circuit. During the time intervals when the Na J detector is operating, the pulses in the rate-meter add a positive charge to the tank condenser. When the anthracene detector is operating, negative charges are added. The recorder thus delivers the difference between the two spectra, i.e. mainly the photo-peaks, provided that the two detectors are suitably matched.

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[1] D. H. PEIRSON, Nature *173*, 990 (1950).

In this laboratory circuits have been developed which perform this automatic subtraction in a multichannel kicksorter of the Hutchinson-Scarrot type.[1] Here the pulses from two detectors are amplified, mixed and continuously fed into the kicksorter. In addition each detector pulse is taken out from the first feed-back-loop of the amplifiers and is shaped by a blocking oscillator to provide a command pulse to a sign-selector circuit in the adding-gate of the kicksorter.

The memory of the kicksorter consists of a magnetostrictive nickel-wire delay-line, where the information is represented in binary form by a circulating pulse-train, the presence or absence of a pulse in a given time position representing a "1" or "0" respectively. If the kicksorter accepts a pulse from the Na J detector, a "1" is added into the channel register corresponding to the measured pulse-height, whereas the acceptance of a pulse from the anthracene detector is followed by the subtraction of a "1".

The sign-selector must be equipped with gating circuits in order to ascertain that the pulse that is accepted and registered by the kicksorter is also the one which determines the sign. It is also necessary to reject coincidences.

By means of a switch the sign-selector can be set at (1) plus-operation, (2) minus-operation, and (3) pulse-operated plus/minus-operation.

This makes it possible to use the kicksorter to reduce the amount of numerical work when background is to be subtracted or spectra from mixtures are to be analysed.

N. G. Sjöstrand, *Department of Physics, Atomic Energy Laboratory, Stockholm*

Determination of an extrapolation length by means of a pulsed neutron method

The exponential experiments which are in progress in our laboratory involve the investigation of different lattices of uranium rods in heavy water. A cylindrical aluminium tank, 1 m in diameter, is used. The wall has a thickness of 1 cm and is covered with 0.4 cm thick boron plastic. This makes the effective radius of the tank difficult to estimate. An experiment has therefore been performed to determine the change of the time constant of the neutron intensity in a small container with heavy water when an extra wall of aluminium and boron plastic is placed around the container. From this change the increase of the effective radius can be calculated.

R. Skjöldebrand, *Department of Physics, Atomic Energy Laboratory, Stockholm*

Some experiments with gaseous scintillators

Some experiments have been carried out to detect fission fragments by means of gaseous scintillators. As detector nitrogen, argon and krypton have been used together with a quartz window photomultiplier. The decay time of the scintillations is shorter than 10^{-8} seconds. The preliminary experiments indicate that spectrometry of heavy particles is possible with this method. Wavelength conversion of the light should probably not be done by means of solid plastic scintillators but by mixing N_2 with one of the noble gases.

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[1] G. W. Hutchinson and C. G. Scarrot, Phil. Mag. *42*, 792 (1951).

EVELYN SOKOLOWSKI, K. EDVARSON and K. SIEGBAHN, *Department of Physics, University of Uppsala*

The effect of the finite size of the nucleus on the probabilities of the 238 keV γ-line conversion in the K, L_{I} and L_{II}-shells of $_{83}\mathrm{Bi}^{212}$

Accurate calculations of conversion coefficients for electric as well as magnetic radiation of different multipole orders have been performed by Rose *et al.* Some investigators have found indications that neglecting the finite size of the nucleus, as was done in these calculations, might have led to appreciable errors. In order to examine this question further a precise measurement was made of the K, L_{I} and L_{II} conversion line intensities of the 238.6 keV γ-transition in ThB, and the K/L_{I} and $L_{\mathrm{I}}/L_{\mathrm{II}}$ ratios thus obtained were compared to those given by Rose for magnetic dipole radiation of the appropriate energy. The experimental and theoretical values were in good agreement. Our measurements as well as those of other investigators seem to establish the pure magnetic dipole character of the transition. Taking into account the possibility of $E2$ mixing masking any other effects, our results lead to the conclusion that, if at all pronounced, the nuclear finite size effect on magnetic dipole radiation should be about equally strong for K, L_{I} and L_{II} conversion.

R. STOCKENDAL, I. BERGSTRÖM, J. A. MC DONELL and M. SCHMORAK, *Nobel Institute of Physics, Stockholm*

Short-lived isomeric states in odd Pb isotopes

Bi^{203} was produced by bombarding pure lead with 40 and 50 MeV protons in the Upsala cyclotron, whereafter the bismuth was chemically separated from the lead. The short-lived lead isomer $\mathrm{Pb}^{203\mathrm{m}}$ was investigated. It was separated from its 12 h bismuth parent by adsorbing bismuth on a small heated ion-exchange column with $0.3M$ HCl. By rapid milkings, under pressure and with $0.3M$ HCl, of the $\mathrm{Pb}^{203\mathrm{m}}$ activity produced in the column and immediate measurements with a movie-photographed multichannel analyzer (and an ordinary single-channel analyzer for better statistics) we found an isomeric transition with energy (0.82 ± 0.01) MeV and half-life (6.4 ± 0.5) seconds. This must be identical with the 825 keV energy found from measurements with the permanent magnet β-spectrograph for photographic recording. A measurement of the scintillation spectrum did not indicate any other γ-ray associated with this isomeric decay.

The systematic relation between neutron number, half-lives and energies of $M4$ transitions in odd Pb isotopes suggests an isomeric transition in Pb^{205} with an energy close to 1 MeV and a half-life of about 1.5 seconds. Using the technique described above we have searched for this isomer, but have only observed the well-known 0.8 seconds (1064 keV) isomer in Pb^{207}, arising from the presence of a small amount of Bi^{207} in the active Bi. However, our measurements do not exclude the possibility of a small feeding of a Pb^{205} isomeric level in the decay of Bi^{205}.

M. STRÅÅT, *Department of Physics, Atomic Energy Laboratory, Stockholm*

The Swedish heavy water reactor. Investigation of radiation leakage through the biological shield

The radiation level in front of the biological shield is calculated to be less than 0.025 millirem/hour. This investigation was intended to trace any rise of background radiation at 100 kW reactor power. The result is presented as isodose curves for slow neutrons and gamma radiation.

W. J. SWIATECKI, *Department of Theoretical Physics and The Gustaf Werner Institute for Nuclear Chemistry, University of Uppsala*

Systematics of fission asymmetry

A general argument indicates that for $Z^2/A < (Z^2/A)_c$ the degree of fission asymmetry should be proportional to $[(Z^2/A)_c - Z^2/A]^{1/2}$. A plot against Z^2/A of the separation between the peaks in the double-humped fission yield curves of 8 elements defines $(Z^2/A)_c = 40.2 \pm 0.7$. A semi-empirical formula for the position of the peaks is deduced.

W. J. SWIATECKI, *Department of Theoretical Physics and The Gustaf Werner Institute for Nuclear Chemistry, University of Uppsala*

Systematics of spontaneous fission half-lives

There is a close correlation between the deviations of the observed half-lives from a smooth dependence on Z^2/A and the deviations δM of the nuclear masses from a smooth reference surface. As a result, if one plots against Z^2/A the experimental half-lives augmented by an empirical correction proportional to δM, a smooth curve is obtained. This is used to deduce an empirical formula involving δM, which reproduces well the experimental half-lives of both even–even and odd–A nuclei.

W. J. SWIATECKI, *Department of Theoretical Physics and The Gustaf Werner Institute for Nuclear Chemistry, University of Uppsala*

Systematics of fission thresholds

An examination of the experimental data on fission thresholds and ground state masses of nine nuclei shows that (i) there is experimental evidence for a difference between the masses of even–even, odd–A and odd–odd nuclei in the deformed Saddle Point configurations, analogous to the well-known difference for the ground states, (ii) the trend with Z^2/A in the *Saddle Point masses* is consistent with simple theoretical estimates, based on a liquid drop type of model. This leads to a semi-empirical formula for fission thresholds, which is found to be consistent also with estimates of thresholds made with the aid of the observed spontaneous fission half-lives of 28 nuclei. An analogous semi-empirical formula for spontaneous fission half-lives is given.

S. T. THOMPSON (Berkeley), E. HJALMAR and H. SLÄTIS, *Nobel Institute of Physics, Stockholm*

On the energy distribution of neutrons from the spontaneous fission of Californium 252

The neutron energies have been measured from the proton recoil tracks in photographic emulsions. The energy distribution has a form similar to that for neutrons from the thermal neutron fission of uranium 235. Referring to the report on the energy distribution, some photographs of fission tracks, obtained by H. Slätis in his low pressure diffusion chamber, are exhibited and discussed.

H. v. UBISCH, *Department of Physics, Atomic Energy Laboratory, Stockholm*

On the natural variations in the abundance of the boron isotopes

As part of work on neutron absorption standards, the ratios B^{10}/B^{11} have been measured on 43 samples of boron minerals and sea water.[1] Contrary to an earlier investigation no variations could be detected except for sea water, where the ratio appears to be about 2 per cent lower than for minerals. If variations occur, they must be smaller than a few promille, and chemicals which show larger variations must have been changed during manufacture.

ULF UHLHORN, *Department of Theoretical Physics, University of Stockholm*

On the formulation of the quantum mechanical density operator as a density-in-phase

The connection between classical statistical mechanics and statistical quantum mechanics is examined in some detail. For systems having no non-classical degrees of freedom any linear operator in the space of state vectors can be represented as a phase function, i.e. a function of the $2n$ variables $p_1 \ldots p_n, q_1 \ldots q_n$. Two types of representation have been considered, corresponding to different modes of writing operators as functions of the $2n$ non-commuting observables $p_1 \ldots q_n$. In the classical limit the two types of representation become identical. The representatives of products of operators and of Poisson brackets are shown to be closely related to the corresponding classical quantities. Infinitesimal unitary transformations are represented by infinitesimal canonical transformations, whereas finite unitary transformations do not in general correspond to canonical transformations. The representative of the density operator can be interpreted as a density-in-phase, satisfying an equation of motion which in the classical limit goes over into Liouville's equation.

B. ÅSTRÖM, *Nobel Institute of Physics, Stockholm*

Determination of α-energies by pulse analysis

As one part of the transuranium element project at the Nobel Institute of Physics there has been designed and built a set-up for the determination of α-energies by means of pulse analysis. The apparatus used consists of an ion chamber and a 16-channel kicksorter.

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[1] A. PARWEL, H. v. UBISCH, and F. E. WICKMAN, Geochimica et Cosmochimica Acta (to be published).

The ion chamber is of the parallel-plate type with a Frisch grid and a special guard electrode surrounding the collector plate. By applying a signal of the same magnitude and phase as the output signal from the chamber to the guard electrode and the grid it has been possible to decrease the virtual capacitance of the chamber to a fraction of its physical value. This gives higher output signals, and less amplification is necessary.

Different gas fillings have been tried in the chamber. Most recently argon with 2 per cent nitrogen added has given very promising results. The best half-widths of the α-peaks so far obtained are 80 keV without use of any collimation. The 16-channel pulse analyzer is of the "stacked" type, using type 6BN6 tubes for determining the different levels and with a dekatron scale-of-10 and a mechanical register in each channel.

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On the motion of charged particles in inhomogeneous magnetic fields

In a hot, ionized gas in a magnetic field the motion of charged particles in inhomogeneous regions of the field is of fundamental importance. An exact treatment is too involved to be tried at present. We have therefore studied the motion in the magnetic field $\boldsymbol{B} = \alpha\,|0, z, y|$. The trajectories in the plane $z = 0$ can be described by elliptic functions and are characterized by a single parameter. The stability for small deviations in the z direction has also been studied.

By elimination of the x coordinate the problem can be discussed as motion in a scalar potential. The motion is generally non-periodic. Up to now we have looked for periodic orbits.

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Isothermal measurements on the release of energy stored in cold-worked aluminium

The release of energy from room-temperature compressed high-purity aluminium bolts has been investigated in the temperature range 70–350°C by isothermal calorimetric measurements with a Borelius type micro-calorimeter. Three different relaxation stages appeared.

At the lowest temperatures used, recovery was obtained in the specimens in line with earlier investigations. The energy of activation calculated for this process is 27 000 cal/mole. At successively raised temperatures, without renewed cold-work of the specimens, a second stage in the annealing process was observed, which was ascribed to subgrain growth and polygonization. The experimentally determined energy of activation for this stage is 36 000 cal/mole. At still higher temperatures primary recrystallization appeared in the specimen, with an energy of activation of 58 000 cal/mole.

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